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An Approach to Studying the Reliability of Microgravity Experiments

Michael Thaggard
Science Applications International Corporation
Brook Park, Ohio

and

Daniel P. Morilak
Lewis Research Center
Cleveland, Ohio

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AN APPROACH TO STUDYING THE RELIABILITY OF MICROGRAVITY EXPERIMENTS

Michael Thaggard
Science Applications International Corporation
Brook Park, Ohio 44142

and

Daniel P. Morilak
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

SUMMARY

The identification of key factors that influence the nonsuccess of experiments conducted under microgravity conditions will aid in the planning, design, and implementation of future space shuttle experiments, as well as other microgravity experiments (i.e., experiments conducted on the Space Station). Similarly, knowledge of the experiments' reliability will assist in forecasting the success of forthcoming experiments. Since a relatively large number of Space Shuttle experiments have been conducted to date, a substantial pool of data exists for assessing the possible causes or factors which influence experiment nonsuccesses. This report details the task being undertaken at NASA Lewis Research Center to measure the Space Shuttle experiments nonsuccess trends and identify causes that significantly affect their performance. It addresses the activities associated with correlating experiment macro-factors with experiment nonsuccesses. The development and implementation of a microgravity database to be used for tracking and correlating experiment nonsuccess factors, as well as the criteria for measuring experiment success and nonsuccess is also discussed.

INTRODUCTION

To date, more than 50 Space Shuttle missions have taken place. During this time a large number of microgravity experiments have been performed on the various missions. To place a given experiment on-board the Space Shuttle for a particular mission involves extensive preparation effort and the investment of a large amount of resources. Therefore, it is important that ways to improve the probability of success of the experiments, when they are performed, be explored so as not to waste the cumulative preparation effort expended in getting the experiments on-board. Several studies have recently been conducted where attention was given to summarizing historical information on previous microgravity experiments. However, no study to date has specifically addressed the problems associated with analyzing the Space Shuttle experiment anomalies and nonsuccess trends. Hence, the principal focus of the study underway at the NASA Lewis Research Center is to analyze the reliability and nonsuccess trends of the Space Shuttle experiments by correlating the experiment macro-factors with their nonsuccesses. It is anticipated that through this analysis process that significant factors which influence or contribute to the experiments' nonsuccess will be identified. The results of the study will be summarized and documented to provide assistance to future experimenters and principal investigators.

Presented here is a brief look at the study underway at NASA Lewis to examine microgravity experiment reliability and nonsuccess trends. Some details regarding the methodology being undertaken to study experiment nonsuccess trends, as well as several of the issues that need to be addressed in analyzing the reliability of space experiments are examined. Particular emphasis is given to probing previous microgravity experiment studies to gain an understanding of what has previously been done in this area.

PREVIOUS EXPERIMENT STUDIES

Other studies have been recently accomplished addressing the nonsuccess of microgravity experiments. Two of these are referenced here for the purpose of gaining an insight into what has previously been accomplished in studying experiment reliability. Although the stated purpose of the previous studies dealt with slightly different issues, they identify approaches for assessing experiment reliability and offer a doctrine for defining and determining experiment nonsuccesses. Issues addressed in the prior studies highlight some of the difficulties surrounding the performance of microgravity experiment studies. In particular, the primary areas of concern involve locating specific experiment information, organizing the experiment data, and assessing the experiment nonsuccess results.

In 1986 Rex Ridenoure conducted a performance study (ref. 1) addressing Get Away Special (GAS) payloads launched to that point in time on the Space Shuttle. The original aim of his study was to generate a listing of all previous GAS experiments performed, so as to assist student GAS experimenters at the Utah State University in understanding what types of experiments had taken place. However, during the process of assimilating the GAS experiment data substantial information regarding experiment anomalies was revealed. Therefore, in addition to generating the GAS experiment list, the results of the GAS experiments were summarized. As a result of Ridenoure's study a complete listing of launched GAS canisters were formulated which detailed all canisters contained on the first 25 shuttle missions. A summary of the GAS experiment results revealed that a sizable number of the GAS experiments experienced some degree of nonsuccess. In addition, it was noted that the largest percentage (58 percent) of the experiment nonsuccesses were related to experiment control and thermal subsystem problems.

Ridenoure GAS study offered an evaluation of several of the space shuttle microgravity experiments. It addressed several important areas for assessing microgravity experiment nonsuccesses. These include the importance of defining what is an experiment success, the need for understanding and categorizing the many different experiment types, and the requirement for understanding the factors which influence an experiment nonsuccess. In addition, his study addressed ways to analyze experiment results.

The second microgravity experiment study recently performed was conducted by a team from Marshall Space Flight Center (MSFC) comprised of Ms. Cheryl Winter and Mr. Jonanthan Jones. In their study, the principal goal was to develop a database containing fluids and materials processing experiments conducted in a low-gravity environment. As part of this effort a database comprised of approximately 600 experiments was developed to include all materials processing experiments performed on U.S. manned space vehicles, on payloads deployed from U.S. manned space vehicles, and on domestic and international sounding rockets. The compilation of data on the experiments in the database allowed the team to assess the nonsuccess of the experiments.

Although, this study focused attention on experiments performed in other environments beside the space shuttle, two hundred twenty eight (228) of the approximately 600 experiments in the database were performed on the space shuttle. These included middeck, payload bay, long duration exposure facility (LDEF), and get-away special (GAS) experiments.

Based on a sample of the experiment results, it was noted that 65 percent of the experiments (of all types) experienced some level of nonsuccess. This study, like Ridenoure's addresses or highlights several important issues that must be dealt with in studying experiment nonsuccesses. In particular, the necessity of understanding what constitutes an experiment nonsuccess is noted, the need for randomizing experiment results so as to minimize the interaction of possible causes, the necessity to characterize the many different experiment types, and the requirement for identifying an appropriate sample size of experiments. In addition, the MSFC study furnish clues for researching and locating experiment data.

The results formulated in the MSFC study highlight the need for performing some type of statistical testing on the experiment results. Without such testing the results are subject to be misinterpreted or could generate question regarding their meaning. In particular, one might ask what experiment types (e.g., biological, combustion, capillarity, fluid physics, and so on) resulted in significant experiment nonsuccesses? On what mission types (i.e., U.S. manned space vehicles, domestic and international sounding rockets, and so on) were the significant experiment nonsuccesses flown? Are the results skewed based on a nonrandom selection process for choosing experiments in the database to study? What useful trends can be obtained from this study to assist future designers in planning microgravity experiments?

These are some of the many questions that must be addressed in order to make sufficient use of the data from previous microgravity experiments. In fairness to the MSFC study it should be noted that the intention of the authors, as indicated previously, was not to study nonsuccess characteristics of previous experiments. Instead their summation of the experiments' results was done as an afterthought to the stated objective of developing an experiments' database. However, these questions as well as many more that could be asked focuses attention to the problems one faces in trying to understand the causes for previous microgravity experiment nonsuccesses.

NASA LEWIS STUDY

Presently underway at NASA Lewis is a study to analyze microgravity experiments conducted on previous space shuttle missions. The study will focus attention on identifying factors which significantly contribute to experiment nonsuccesses. In particular, experiment reliability trends will be examined and correlated to evaluate significant causes that influence experiment nonsuccesses.

The NASA Lewis study will be accomplished in basically five phases. Each phase is discussed below. Several of the phases involve the performance of concurrent activities. Hence, there is considerable overlap between the phases and the activities within the phases.

Experiment Definition Phase

This phase involves developing a list of previous microgravity experiments and formulating a detailed reference source listing to provide an avenue for obtaining flight mission data, experiment science objectives and published results and findings. Several sources have presently been identified and are being used to research and compile information on previous shuttle experiments. They include: NASA RECON and ARINC Systems, Johnson Space Center's Automated Mission, and Payload Tracking System (AMPTS) database, NASA Lewis' Mission Operations Reports (MOR's), Space Shuttle Mission Press Kits, and numerous publications submitted by the various experiment principal investigators (PI's).

Researching experiment information has proven in the past to be a very challenging effort. The authors of both of the previous studies noted the difficulties encountered in attempting to locate specific experimental data. The greatest hardship appears to be associated with finding published results or findings for the experiments. Because of the diversity of experiment types conducted on the Space Shuttle, multiple publication sources are utilized by the PI's in publishing the results of their experiments. In particular, locating published papers for experiments headed by foreign investigators has proven to be the most challenging.

Compile Experiment Data Phase

The development of a microgravity experiment database is required to compile specific information on each of the experiments. The database permits the storage and tracking of experiment data needed in correlating experiment nonsuccess factors. Currently, a microgravity database is under development at NASA Lewis. The database in its present state contains data for approximately 370 experiments conducted on the first 40 space shuttle missions (i.e., STS-01 to STS-39). Contemporary experiments are not included due to the anticipated difficulties in obtaining published results for experiments recently conducted. Also, GAS experiments, Long Duration Exposure Facility (LDEF) experiments and Student Experiments (SE) have been excluded from the database because of the uniqueness associated with these particular experiments.

The development of the database structure has concentrated on including specific data fields needed in studying experiment reliability trends. Shown in appendix A is a sample of the types of data that is being collected for each experiment. However, it should be noted that since this database is still under development the data fields identified may change during the course of the study.

Design of Experiment Phase

It is anticipated that multiple factors at multiple levels will be examined in assessing the significance of each factor on the experiments' nonsuccess. Therefore, a statistical design of experiment technique will be formulated to analyze the significance of the individual factors, as well as the significance of the interaction between factors.

The use of a design of experiment approach is important in assessing experiment nonsuccess causes. To simply identify dominant nonsuccess causes will not provide a true measure of potential problem areas. Nor does it furnish future experimenters with any useful information. For example, Ridenoure's GAS study reveals that "experiment control" and "thermal" problems dominated the nonsuccess history of GAS experiments. These represented 58 percent of the experiment nonsuccess problems. However, the significance of the results are not clearly defined. In this case since the results are based on a sample size of 50 and the interactions between experiment nonsuccess causes are not figured, then the statistical significance of the experiment nonsuccess causes would have to be measured before any conclusions can be drawn from the results.

Although the proposed design of experiment technique has yet to be determined, it is anticipated that some form of a randomized fractional factorial experiment will be used. In general, a fractional factorial experiment is one in which several levels of a given factor are combined with several levels of every other factor in the experiment. The fractional factorial method has been proven to be more efficient than other test strategies. Thus, if there are five levels of the factor, "experiment types" (i.e., biological, crystals, astronomy, fluids, and metals/alloys) considered at three levels of the factor, "experiment locations" (i.e., orbiter middeck, cargo bay, and spacelab module), this would be a 5×3 factorial experiment. Or, 15 different experimental conditions would have to be considered for a simple factorial experiment. However, the fractional factorial uses only a portion of the total possible combinations to estimate the significance of the main factor effects and some, not all, of the factorial interactions. Thus, requiring fewer combinations. Presented in table I is a sample of several of the factors to be considered in formulating the design of experiment technique for this study. The table also identifies the number of potential levels associated with each factor as well as a description of the levels. Because of the large number of factors with multiple levels to be considered the use of a fractional factorial experiment design is further warranted.

Analyze Experiment Reliability and Nonsuccess Trends Phase

The design of experiment technique addressed above and the nonsuccess factors identified, will be used to track significant factors influencing experiment nonsuccess. As part of this effort, search routines will be formulated to assist in performing comprehensive searches of the database to locate experiments that meet a specific nonsuccess criteria and certain factorial combinations. Hence, the significance of the various factors influence on the experiments' nonsuccess will be correlated and identified based on the records in the database that meet all the prescribed search routine conditions. For example, a logic statement similar to the following might be used to identify all experiments contained in the database that meet the criteria of having had anomalies, did not achieve all experiment objectives, stored in a middeck locker, weights greater than 50 lb, flown on a flight with an altitude greater than 160 nm, flown on a flight launched at an inclination of 28.5°, and so on:

AE .AND. OM .AND. ML .AND. W50 .AND. A160 .AND. I285 .AND. ...

where

AE	anomalies experienced
OM	objectives met
ML	contained in middeck locker
W50	weight > 50 lb
A160	altitude > 160 nm
I285	inclination = 28.5°

For this example, nonsuccessful experiments (i.e., experiments experiencing anomalies and not achieving their objectives) contained in the database are located and selected when they are at prescribed levels of the four factors addressed (i.e., ML, W50, A160, and I285). Here, the .AND. logic implies that all conditions of the logic string must be satisfied in order for the experiment to be identified in the search. This sets two constraints on the analysis process:

1. Search strings must be formulated to address specific factors that are being considered, which implies several iterations of searches are necessary to implement the design of experiment procedure outlined above.

2. Data contained in the microgravity database must contain factorial information on each experiment to permit the types of searches necessary.

The approach to be employed in using the design of experiment technique involves assessing factors at two levels during the initial iteration. The interaction between factors are randomized so as not to bias the significance of the factor interactions. Subsequent iterations of the screening process (i.e., identification of experiments meeting a set of prescribed conditions) will measure the effect of additional levels of each factors found during the initial iteration to be significant.

Document Results Phase

The results of the study will be documented and a report developed to identify factors which influence the nonsuccess of the experiments. The aim is to make the reported results available to all NASA Centers to provide the most useful information to future experimenters. It is anticipated that the results will include a summary of the factors that significantly influence experiment nonsuccesses. In addition, a greater understanding of potential causes for experiment nonsuccesses should be detailed.

MICROGRAVITY EXPERIMENT RELIABILITY

One of the more challenging aspects of studying microgravity experiment nonsuccesses is understanding what constitutes an experiment nonsuccess. Comprehending the experiments' nonsuccess is important for understanding the reliability of the experiments. Both the GAS and MSFC studies addressed the issue of defining and determining experiment success and nonsuccess. However, the essential issue is that there exists several different definitions and a variety of ways to define experiment nonsuccess. In particular, four definitions are provided in the MSFC paper (ref. 2) for experiment success. These include the following:

1. An experiment is recognized as successful if the principal investigator (PI) addresses a scientific problem worthy of low-gravity investigation, participates in the preparation of the experimental hardware, conducts extensive ground-based research in preparation of the experiment, meets safety and other flight requirements, and realizes the integration of the experiment into the low-gravity vehicle.

2. The success of the experiment is measured by the lack of external anomalies which occurred during the course of performing the experiment.

3. The experiment is considered successful if it addresses the planned scientific objectives and demonstrates the expected investigative results.

4. The experiment is deemed successful if it demonstrates favorable materials processing and/or fluid manipulation results.

For the NASA Lewis study, the first and fourth definitions are not appropriate. Use of the first definition would only provide a measure of how often the PI's were able to get their experiment on-board the shuttle. The fourth definition only addresses materials processing experiments. To use this definition would result in a study that only includes materials processing experiments (i.e., a small portion of the total number of experiments that should be included). The MSFC study focuses attention to this definition because only materials processing experiments are included in the MSFC micrograviy database. Therefore, it would appear that either the second or third definitions should be considered for use in defining experiment success (and nonsuccess) in this case. the argument can be made that both definitions represent some form of how well the experiment performed, depending on from whose perspective it is judged. Clearly, the PI's would consider their experiment to be less successful if all of the experiment objectives were not achieved. Similarly, the equipment designer(s) (which also could be the PI's) and most reliability engineers would recognize equipment malfunctions or anomalies that occurred during the performance of the experiment to mean the experiment was somewhat unsuccessful. The key to using either or both definitions is to recognize that the objective here is to assess and measure nonsuccess trends so as to offer ways to improve future implementation of space shuttle experiments. Therefore, it would appear that a combination of the two definitions, similarly to the method employed by Ridenoure in his GAS study, is the most appropriate.

In general, the reliability function (also known as the survival function) represents the probability that a system (or product) will be successful at least for some specified time, t. The reliability, R(t) is defined as

$$R(t) = 1 - F(t) \tag{1}$$

where F(t) is the probability that the experiment will be nonsuccessful by time, t. Here, time, t covers the period of time when the experiment is performed on-orbit in the shuttle. The function, F(t) is the conditional probability that the experiment will have an anomaly (i.e., success definition two) and the probability that one or

more of the experiment objectives have not been met (i.e., success definition three). Therefore, F(t) is expressed as follows:

$$F(t) = P(C_2|C_1) = \frac{P(C_2 \cap C_1)}{P(C_1)} \tag{2}$$

where C_1 represents a condition 1 experiment nonsuccess and C_2 represents a condition 2 experiment nonsuccess. Based on the above definitions, a condition 1 experiment nonsuccess embodies an experiment that experiences one or more anomalies. Similarly, a condition 2 experiment nonsuccess includes an experiment that did not achieve one or more of its scientific objectives. More simply stated, the experiment nonsuccess function represents the probability that an experiment did not achieve all of its scientific objectives given that the experiment experienced some anomalies. Based on the use of this formula, a reliability figure of merit can be established for the 117 active experiments in Ridenoure's GAS study. Here, 45 of the experiments were considered successful in that all the science objectives were met, no anomalies were experienced or both. Therefore,

$$P(C_2 \cap C_1) = \frac{(117 - 45)}{117} = 0.385 \tag{3}$$

where

$P(C_2 \cap C_1)$ = probability of experiment with anomalies and not achieving all experiment objectives

and since 72 of the 117 active experiments did not achieve all of their scientific objectives then:

$$P(C_1) = \frac{72}{117} = 0.615 \tag{4}$$

Thus, F(t) = 0.385/0.615 = 0.625 and

$$R(t) = (1 - 0.625) = 0.375 \tag{5}$$

This is slightly different than if we use the expression $R(t) = P_s$, where P_s represents the probability of success. here, R(t) = 45/117 = 0.385, which is slightly higher than the conditional probability found earlier.

Knowing the reliability of the microgravity experiments is important for assessing future experiment designs and understanding nonsuccess trends. The primary issue here is understanding the factors that significantly influence the experiments' reliability. Traditionally, reliability engineers investigate causes that contribute to hardware failures. However, since in this case the experiment reliability is not just a function of hardware anomalies, other influential factors will have to be considered. These factors might include the location of the experiment in the shuttle, the type of experiment, the level of crew involvement in performing the experiment, the number of other experiments conducted on the mission, the experiment interfaces, and so on.

The NASA Lewis study as addressed above will screen experimental factors that significantly influence experiment nonsuccesses. The key word here is significantly. Ridenoure's GAS study focused attention to several experimental nonsuccess cause categories. These included: experiment control problems (i.e., blown fuses, ground loops, dead batteries, and so on), mechanical design problems (i.e., cracked boxes, damaged hardware during shipment, broken glass tubes, and so on), power supply failures, thermal design problems, atmospherics conditions, and science design problems. However, a design of experiment test is needed to assess the significance of each potential cause so that an understanding can be obtained as to whether a given dominant cause is truly a problem or simply results from having more experiments of a particular type in the sample of experiments. For example, in the GAS study if 58 percent of the experiment nonsuccesses resulted from experiment control and thermal problems then can it be stated that this resulted from having more GAS experiments susceptible to these types of problems in the experiment pool or are these problems a significant cause of GAS experiment nonsuccess? As a further illustration, if we have 25 experiments (contained in a sample of 50) with experiment control subsystems, where ten of them are judged nonsuccessful, then it might be state that "experiment control" anomalies contribute to 20 percent of the experiment nonsuccesses. Are these anomalies more significant than if we had four (4) power supply experiments in the sample size and two of the experiments experience a nonsuccess? Then it might be asserted that power supply anomalies confer 4 percent (2 out of 50) of the experiment nonsuccesses.

However, looking at it from a different perspective only 40 percent (10 out of 25) of the "experiment control" experiments resulted in a nonsuccess, whereas 50 percent (2 out of 4) of the "power supply" experiments experienced a problem. Which is more significant? To answer this question requires and evaluation of the statistical significance of the results.

OUTLOOK

The two previous microgravity experiment studies provide us with a good understanding of the approach needed to assess experiment nonsuccess. In addition, both studies highlight problem areas that one needs to resolve in order to study the experiments and provide useful reliability information for future experimenters. The NASA Lewis study will utilize the experience gained from these previous efforts to conduct a detail reliability analysis of the Space Shuttle experiments with the goal of providing future experimenters with information to enhance the performance of their experiments. This not only includes quantifying the reliability of previous shuttle experiments but also identifying nonsuccess trends to distinguish areas of improvement in planning, developing and implementing forthcoming microgravity experiments.

The performance of microgravity experiments in the Space Shuttle environment requires a large expenditure of resources in both manpower and money. Many of the experiments performed on the Space Shuttle require several years of planning, development and testing before they are carried out on a particular mission. Although it can be argued that there are many different ways of defining an experiment success, all experiments determined to be less than successful results in the waste of limited resources. Thus, it is essential that any and all ways of improving the reliability of the microgravity experiments be explored. This study will attempt to do this by presenting useful results to future experimenters to improve the reliability of their experiments.

The compilation and development of the microgravity database at NASA Lewis has already provided some initial residual benefits to several of the Safety engineers working on upcoming Space Shuttle experiments in that it has provided useful reference materials for assessing the risks associated with the experiments they are involved with, since this activity is bringing about the generation of a large reference repository on microgravity experiments. Although this is not the focus for assessing the experiments' nonsuccess trends, it is anticipated that additional residual benefits beyond those addressed above will be realized from this study effort.

APPENDIX A
(SAMPLE DATABASE RECORD)

EXPERIMENT INFORMATION

EXPERIMENT NAME:	Shuttle Imaging Radar
ACRONYM: STR-B	ASSOCIATED PAYLOAD: OSTA-3 EXPERIMENT NUMBER: E441

OBJECTIVE:

Provide maplike images useful in delineating geological features and in evaluating resources.

Specific objectives include the following:

— To evaluate the utility of radar imagery acquired under different surface viewing conditions for various types of surface observations.

— To determine the extent to which subsurface radar penetration occurs in arid environments.

— To develop improved models of radar backscatter from vegetated terrain and marine areas.

FINDINGS:

Only about 25 percent of the prime digital data were acquired due to problems with the deployment of the radar antenna and with the pointing of a data relay antenna. Nevertheless, high-quality images were acquired over key test sites in the United States (Florida, Hawaii, Illinois, and Nevada), as well as in foreign countries.

A number of problems occurred during the SIR-B mission that prevented acquisition of the complete set of planned imagery. The first problem occurred on the first day of the mission after the first SIR-B data take. The Ku-band antenna that was used to transmit digital data to the TDRS relay satellite lost its drive mechanism. It began oscillating from side to side making it impossible to track TDRS. The problems was partially remedied by disconnecting the antenna pointing control and locking the Ku-band antenna in a fixed position so that the power could be applied without creating the oscillations. In this locked position, the entire shuttle had to be maneuvered in order to transmit digital SIR-B data to the ground. The new mode of operation for SIR-B then was to acquire 20 min of data on the on board tape recorder, and then put the shuttle in its TDRS tracking attitude. Under these circumstances, the total planned data had to be cut by about 80 percent, thus allowing only 8 hr of data acquisition versus the 40 hr originally planned.

A second problem resulted in a loss of about 16 dB round trip in the antenna feed. A particle in the antenna feed cable was causing arching resulting in a transmitted power that was 8 dB less than planned.

APPENDIX A
(SAMPLE DATABASE RECORD CONT'D)

DOCUMENT LIST: JSC AMPTS Database; Payload Flight Assignments NASA Mixed Fleet; Spacelab and Attached Missions - OSSA
Flight Systems Division; IEEE Transactions on Geoscience and Remote Sensing, July 1986, Vol. GE-24, No. 4;
Prelaunch Flight Operation Report, M-989-41-G;
Post-Flight Flight Operation Report, M-989-41-G;
Post Launch Mission Operation Report, E-420-41-G-09;
Space Shuttle Mission 41-G Press Kit

EXPERIMENTAL UPWEIGHT EXPERIMENTAL DOWNWEIGHT: INTERFACE:

ALTITUDE REQUESTED: 190.00 REQUESTED INCLINATION: 57.00

MINIMUM TIME ON-ORBIT (DAYS): 8 NUMBER OF LOCKERS: 0

PROBLEMS ENCOUNTERED?: YES TYPE CODE: 1 LOCATION CODE: B2

DURATION: 8:00 ITERATION: 2 SET-UP TIME: 0.00

EXPERIMENT APPARATUS:

EXPERIMENT HARDWARE: Shuttle Imaging Radar

STORAGE CONTAINER: NONE STORAGE LOCATION: PAYLOAD BAY

ORBITAL CREW INVOLVEMENT: GROUND CREW INVOLVEMENT:

GROUP: NASA/JPL ORGANIZATION CODE: A

P.INVESTIGATOR: C. Elachi CO-INVESTIGATOR:

NASA CENTER: JPL

SHUTTLE MISSION DATA

SHUTTLE FLIGHT: 41-G ORBITER: Challenger FLIGHT DATE: 10/05/84

FLIGHT DURATION: 192.00 INCLINATION: 57.00 ALTITUDE: 190

CREW SIZE: 7 NUMBER EXPERIMENTS ON-BOARD: 18

ELAPSED TIME BETWEEN PREVIOUS FLIGHT: 720.00 HR

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TABLE I.—SAMPLE EXPERIMENT FACTORIAL LAYOUT

Factors	Number of levels	Description of levels
Experiment type	8	Metals/alloys; biological; combustion; fluids and chemicals; crystals; environments; astronomy; radiation
Experiment location	6	Middeck locker; MEA; MPESS; hitchhiker; spacelab module spacelab pallet
Experiment duration	5	< 12 hr; 12 to 24 hr; 25 to 36 hr; 37 to 48 hr > 48 hr
Weight	4	<100 lb; 100 to 500 lb; 500 to 1000 lb; >1000 lb
Inclination angle	5	28.5°; 38.0°; 40.3°; 50.0°; 57.0°
Altitude	7	120 to 130 nm; 131 to 140 nm; 141 to 150 nm; 151 to 160 nm; 161 to 175 nm; 176 to 200 nm; >200 nm
Pad weather	6	0 to 25 °C w/ < 75 percent humidity; 0 to 25 °C w/ ≥ 75 percent humidity; 26 to 40 °C w/ < 75 percent humidity; 26 to 40 °C w/ ≥ 75 percent humidity; >40 °C w/ < 75 percent humidity; >40 °C w/ ≥ 75 percent humidity
Number of experiments onboard	5	1 to 5; 6 to 10; 11 to 15; 16 to 20; >20
Number of payloads on onboard	5	1 to 5; 6 to 10; 11 to 15; 16 to 20; >20
:	:	:

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13. ABSTRACT (*Maximum 200 words*)

The identification of key factors that influence the nonsuccess of experiments conducted under microgravity conditions will aid in the planning, design and implementation of future space shuttle experiments, as well as other microgravity experiments (i.e., experiments conducted on the Space Station). Similarly, knowledge of the experiments' reliability will assist in forecasting the success of forthcoming experiments. Since a relatively large number of Space Shuttle experiments have been conducted to date, a substantial pool of data exists for assessing the possible causes or factors which influence experiment nonsuccesses. This report details the task being undertaken at NASA Lewis Research Center (LeRC) to measure the Space Shuttle experiments nonsuccess trends and identify causes that significantly affect their performance. It addresses the activities associated with correlating experiment macro-factors with experiment nonsuccesses. The development and implementation of a microgravity database to be used for tracking and correlating experiment nonsuccess factors, as well as the criteria for measuring experiment success and nonsuccess is also discussed.

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